(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 199 401**
B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification: **12.09.90**

(51) Int. Cl.[5]: **H 01 H 85/04,** H 01 H 85/42

(21) Application number: **86200571.7**

(22) Date of filing: **03.04.86**

(54) Fuse.

(30) Priority: **04.04.85 NL 8501004**

(43) Date of publication of application:
29.10.86 Bulletin 86/44

(45) Publication of the grant of the patent:
12.09.90 Bulletin 90/37

(84) Designated Contracting States:
BE CH DE FR GB IT LI LU NL SE

(56) References cited:
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DE-B-1 160 079
GB-A- 732 428
GB-A-1 166 490
US-A-1 687 246
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EP 0 199 401 B1

Courier Press, Leamington Spa, England.

Description

This invention relates to a fuse of the miniature and sub-miniature type having dimensions not exceeding 6,3 x 32 mm and having an interrupting capacity in the order of 1500A, comprising a fuse element arranged between two end caps in a housing, said fuse element being at opposite ends in contact with said end caps.

In US Patent 4 369 421 a fuse is described comprising a fuse element arranged between two end caps in a housing, said fuse element being at opposite ends in contact with said end caps. The fuse element proper is a thin metal wire extending diagonally through the housing and having its ends damped between the wall of the housing and the inner wall of the end cap concerned. No dimensions are mentioned in the reference.

Similar fuses of the miniature and sub-miniature type are generally known. In such fuses, operated at relatively low voltages (up to, for example, 250 V) sometimes a high interrupting capacity is desirable. A desired interrupting capacity of 1500A is not unusual, but the interruption of higher current intensities of, for example, 5 to 6 kA is sometimes required. When high current intensities are interrupted, arcing occurs. If this arc is not quenched or insufficiently so, the interruption is not effective or too late. In order to quench the arc, fuses designed for use with high interrupting capacity are commonly filled with fine sand or quartz sand. The manufacture of such sand-filled fuses, however, involves higher cost than the manufacture of non-filled fuses. There is accordingly a need for fuses which need not be filled with sand or the like but yet have a high interrupting capacity.

It is an object of the present invention to fulfil the need outlined above. This subject is achieved in that the cylindrical housing comprises transversely to the axis of the housing a pair of grooves whereby the end caps are engaged in the grooves and the housing and the end caps are firmly held together, said housing comprising an inner cavity in form of an at least semi-cylindrical hole, which is not filled with a particulate arc-suppressing filling and has a cross-section less than 10 mm, said housing consisting at least in part of ablative material, which material dissociates at high temperature at least at its surface to release gases which suppress arcing when said fuse element blows.

In the fuse of the invention the hole in which the arc is burning after blowing of the fuse has a cross-section of less than 10 mm. With such cross-section the ablative effect is the most effective, since such cross-section is of the same order of magnitude at the cross-section of the arc. It is a characteristic feature of the fuse of the invention that an ablative material is used in the housing. As mentioned ablative material means a material from which, upon heating, from the arc forming when the fuse element blows, gas is released which has a favourable effect on the current interrupting characteristics of the fuse, because the arc is rapidly suppressed or quenched. Some materials are already ablative by nature, for example, polytetrafluoroethylene, polyimide, melamine, polysulfon and the like. Other materials can be rendered ablative, for example, by the adsorption of gas to a surface thereof. One example is quartz with fluorine adsorbed to its surface.

In the fuse according to the present invention, preferably the housing is made of an ablative material, or at least the portion of the housing bounding the inner surface is made of ablative material. Suitably, also, the fuse may consist of a carrier of ablative material with a tin coat of metal on it.

It is noted that in US-A-3 913 051 a fuse having small dimensions is disclosed. However, the envelope or housing of said known fuse does not support the structure. A carrier body supporting a fusible element is provided. The housing is a heat-shrinkable tubing surrounding said carrier body and fusible element. The resulting structure cannot be said to comprise a closed cavity that can withstand high arc voltages. The disclosed structure therefore is concerned with protection of circuits carrying currents up to 5A and voltages up to 125V.

It is further noted that the use in fuses of material, from which, upon heating, material is released, is known per se. Thus the above US patent 4 369 421 discloses a fuse consisting of a metallic core with a cladding of synthetic plastics material. Upon heating the plastics is decomposed to release hydrochloric acid, which acid reacts with the metal of the conductor and reduces the cross-section thereof. There is no reference to an ablative material within the meaning of the present invention. Furthermore, Netherlands patent application 8005419 discloses a fuse whose cylindrical envelope is built up from a tubular outer member and a tubular inner member. The inner member is made of a material of high thermal conductivity and low thermal shock resistance. When an electrical overload current is passed through the fuse element, the inner member is fragmented. The resulting heat and vapours are absorbed by the fragmented parts. Other than the present invention, this known fuse at any rate requires an envelope built up from two concentric tubes. This requirement will tend to increase cost of production.

It is further noted that a fuse consisting of an envelope containing a carrier with a thin metal coat thereon is known per se, for example, from Netherlands patent application 7906716. This prior construction does not, however, have a carrier of ablative material.

One suitable embodiment of the fuse according to the present invention is characterized in that the housing comprises a solid portion in the form of a solid semi-cylinder, on which solid portion the thin metal coat of the fuse element is arranged, and of a portion hooding said solid portion which hood portion substantially has the shape of a half, hollow tube. In this embodiment

the end caps are preferably each provided with a central, inwardly directed, frusto-conical portion depressed from the end surface, and the solid portion of the housing is provided adjacent each of its ends with a semi-conical depression in its surface, on which the thin metal coat is provided, the arrangement being such that the inwardly directed, frusto-conical portion of each end cap is in contact with the thin metal coat provided in the adjacent conical cavity in the surface of the solid portion of the housing.

In the fuse according to the invention, arcing may still occur as the fuse element blows. In the short time between the formation of the arc and the suppression thereof by gas released by the ablative material, the arc could reach the end cap, which is undesirable. In order to avoid this, a bored plug may be provided within the housing adjacent each of the end caps, with the fuse element being passed through each of the bores to contact the end caps. Suitably, the bore through each plug may take an angle with the axis of the housing.

If the housing consists of a plastically deformable material, it is also possible for the plugs to be formed as an integral part of the housing, for example, as an inwardly directed, thickened portion of the housing. Instead of, or in addition to, plugs a pierced metal plate may be disposed adjacent each of said end caps.

The invention will now be described with reference to the accompanying drawings in which:

Fig. 1 is a cross-sectional view of one embodiment of the fuse according to the invention.

Fig. 2-5 are cross-sectional views of an end of various embodiments of the fuse according to the invention.

Fig. 6 is a cross-sectional view of still another embodiment of the fuse according to the invention.

Fig. 7 is a cross-sectional view of an end of a further embodiment of the fuse according to the invention.

Fig. 8 is a cróss-sectional view of yet another embodiment of the fuse according to the invention.

Fig. 9 is a cross-sectional view, taken on the line IX-IX of Fig. 8.

Fig. 10 is a perspective view showing a part of the fuse illustrated in Fig. 8.

Fig. 1 illustrates one embodiment of the fuse according to the invention, comprising a substantially cylindrical housing or envelope 1. Arranged within housing 1 is a fuse element 2, for example, consisting in known manner of a thin metal wire or a coil of thin metal wire wound about a carrier wire, which, in either case, may or may not be provided with fuse beads. The fuse element 2 is arranged diagonally within housing 1, with its ends being curved around the edge of housing 1. The ends are clamped between the edge, i.e. the end of housing, 1 and suitable end caps 3 and 4 slipped over the ends of housing 1. Housing 1 consists of a preferably plastic, ablative material. Provided along the circumference of housing 1, transverse to the axis of housing 1 are a pair of grooves 5 and 6. The ends 7 and 8 of the annular part of end caps 3 and 4, which are directed somewhat inwardly, engage in grooves 5 and 6, so that the various parts of the fuse are firmly held together. As shown, the fuse wire 2, the ends of which are bent around the edge of housing 1, may be taken of such length that these ends extend into the grooves and 6, so that they are additionally clamped under the ends 7 and 8 of the end caps. This will further improve the electrical contact between fuse wire and end cap, while soldering the fuse wire to the end caps is entirely superfluous.

The end caps 3 and 4 of the fuse as shown may consist of a material commonly used for end caps, for example, of nickel, nickel-plated brass, silver-plated copper and other metals. The metal wire of the fuse element may also consist of metals commonly used for fuse elements, for example, tin, copper, silver and the like. The housing 1, which may consist of a single cylinder or of two half cylinders placed one upon the other, is made of an ablative material, by which we mean a material from which, at elevated temperature, from dissociation, a gas is released which suppresses the arc as the fuse element blows. Suitable ablative materials are plastic, synthetic plastics materials having a good mechanical strength and resistance to the high temperatures which occur when the fuse blows. Examples of such materials are those known by their tradenames Victrex PEEK, both non-filled and glass-fibre-filled, Arnite, Ryton R4, Polysulfon and High Heat Lexan. It is also possible, however, to use a housing 1 of a known per se non-ablative material of which, however, the surface portion on the inside has been processed to render it ablative. One example is a housing of quartz with fluorine adsorbed in the inner surface thereof.

In miniature and subminiature fuses (dimensions for example 5×20 mm or 6.3×32 mm) a filling of fine sand has hitherto been used for high interrupting capacities (current intensities of more than 1500A), which sand served to suppress or quench the arc occurring as the fuse blows. By using an ablative material according to the present invention such a filling of sand can be omitted. The role of the sand is, as it were, taken over by the gas released from the ablative material. This will especially be the case if there exists so to say a direct contact between the wall material and the ionised gas forming the arc, meaning in general that the radial expansion of the arc column is limited by the presence of the wall. So the dimensions of the hole in which the arc is burning should preferably be of limited values. In normally sized miniature fuses, having for instance the dimensions mentioned hereinabove, such a requirement is fulfilled in general. It may, however, be clear that the ablative action not only occurs in cylindrical holes, but also in other shaped holes or cavities of suitable dimensions.

Fig. 2-5 illustrate cross-sectional views of one

end of various embodiments of the fuse according to the invention. Corresponding parts are provided with the same reference numerals as used in Fig. 1.

The end of the fuse shown in Fig. 2 comprises adjacent its end a plug 9 in the cylindrical housing of ablative material. Plug 9 consists of a suitable insulating material which, if desired, may also be ablative. The plug 9 is provided with a throughbore 10 which is at an angle to the axis of housing 1. The fuse element 2 is passed through the bore 10. One object of the provision of plugs 9 adjacent to the ends of cylindrical housing 1 is to prevent the plasma jet accompanying the arc formed when the fuse element blows from hitting the end cap 3 before the arc is suppressed by the gases released from the ablative material of housing 1, which could have undesirable results. Having throughbore 10 extend at an angle to the axis of housing 1 is an additional contribution towards this goal. Good results were achieved with a fuse as shown in which housing 1 consisted of High Heat Lexan with plugs 9 being also formed of High Heat Lexan, while end caps 3 and 4 of nickel-plated brass were used with a fuse wire of copper coated with tin, diameter 100/m. A fuse bead, consisting of a droplet of tin, was provided in the centre of the fuse wire.

Another possibility of preventing the end cap from being hit by a possible plasma current is shown in Fig. 3. Instead of a bored plug of insulating material, a pierced metal disc 11 is arranged on, or in, the end of housing 1. In the case illustrated, disc 11 is clamped between the end of housing 1 and the rear end of the sleeve-shaped end cap 3. Fuse element 2 is passed through the aperture in disc 11 and clamped between housing 1 and end cap 3 in the manner discussed with reference to Fig. 1.

A combination of an insulating plug and a metal disc is shown in Fig. 4. In that embodiment, plug 12 and metal disc 13 are formed, as it were, as an integral part. The throughbore 14 through plug 12 and disc 13 is, in this embodiment, concentric with housing 1.

Fig. 5 shows still another embodiment of the way of arranging a plug and fastening a fuse element. In that embodiment, fuse element 2 is passed through a bore 15, concentric with housing 1, through a plug 16 of insulating material provided adjacent the end of housing 1. Fuse element 2 is secured to end cap 3 by means of a solder mass 17.

Fig. 6 illustrates a cross-sectional view of a suitable embodiment of the fuse according to the invention. In that embodiment housing 1 consists of a plastic or deformable ablative material. In the manufacture of the cylindrical housing 1, which may be built up from two half cylinders, inwardly directed beads or ridges 18 and 19 are provided adjacent the ends, which ridges 18 and 19 have a similar function to the plugs in the embodiments illustrated in Fig. 2, 4 and 5. The plasma jet preventing effect can be enhanced still further by the use of a pierced metal plate or disc 20 between end cap 3 and ridge 18, as illustrated in Fig. 7. Incidentally, plugs, discs and/or ridges can help to keep fuse element properly centred within housing 1 in all of the embodiments discussed.

Fig. 8-10 illustrate a different embodiment of the fuse according to the invention. Fig. 8 is a cross-sectional view; Fig. 9 shows a sectional view taken on the line IX-9 of Fig. 8; and Fig. 10 gives a perspective view of a portion of a part of the device shown in Fig. 8. Like parts in Fig. 8-10 are designated by like reference numerals.

The fuse illustrated in Fig. 8-10 comprises a carrier body 21 in the form of a solid half cylinder of an ablative material. Secured to carrier 21 is a half hollow tube 22, which half hollow tube 22 also consists of an ablative material. Carrier 21 and half tube 22 together form a cylinder with a cavity therein defined by the upper surface of carrier 21 and the inner surface of the half tube 22. The half hollow tube 22 is arranged to fit carrier 21, for example by the edges of tube 22 engaging in longitudinal grooves 23 in carrier 21, as shown in Fig. 9. Half hollow tube 22 and carrier 21 are kept clamped together by end caps 24 and 25 slipped over the ends of the assembled cylinder. End caps 25 and 24 each consist of a base and an annular upstanding rim, which annular upstanding rim engages around the assembled cylinder formed by carrier 21 and half tube 22. At the end of the annular upstanding rim of end caps 24 and 25 away from the base, the annular rim is curved slightly inwardly as indicated at 26 and 27. Suitable grooves 28 and 29, extending transverse to the axis, are formed in the outer surface of half tube 22. Similarly, suitable grooves 30 and 31, transverse to the axis are provided in the outer surface of carrier 21. The inwardly curved rim 26 of the end cap 24 engages in grooves 28 and 30, and the inwardly curved rim 27 of end cap 25 engages in grooves 29 and 31, so that a firm and rigid construction in ensured. Further it is possible to connect carrier 21 and half tube 22 directly to each other in a proper way, e.g. by welding.

Formed in the plane upper surface of the solid carrier 21, adjacent each of the ends, is a semi-conical recess 32 and 33, respectively. Provided on the upper surface of carrier 21 is a fuse element in the form of a thin metal coat 34. In the embodiment shown, metal coat 34 is of such shape that the coat is broad at the ends of the carrier, where it also covers the semi-conical recess 32 and 33, and becomes narrower towards the centre of carrier 21. Naturally it is possible for fuse elements to be made of different design, for example, as a coat which is equally broad throughout the entire carrier with a thinned or tapered portion adjacent to the center of the carrier. The plane surface of the carrier 21, on which the metal coat 34 is provided, need not necessarily be smooth. Grooves or pits may suitably be formed in this surface. It has been found that, with a suitably selected pattern of grooves or pits, the interruption behaviour of the fuse, particularly as regards time and place of interruption, can be influenced.

The base of end cap 24 is provided with a central, inwardly directed, frusto-conical portion 35 recessed from the base surface. Similarly, end cap 25 is provided with a similar frusto-conical portion 36. When end caps 24 and 25 have been placed in position, the frusto-conical portions 35 and 36 press against the metal coat 34 applied over the semi-conical cavity 32 and 33 in carrier 21. There is thus obtained a good electrically conducting contact between end caps 24 and 25 and the metal coat 34 forming the fuse element.

Claims

1. A fuse of the miniature and sub-miniature type having dimensions not exceeding 6,3 x 32 mm and having an interrupting capacity in the order of 1500A, comprising a fuse element (2) arranged between two end caps (3, 4) in a housing (1), said fuse element (2) being at opposite ends in contact with said end caps (3, 4), characterized in that the cylindrical housing (1) comprises transversely to the axis of the housing a pair of grooves (5, 6) whereby the end caps (3, 4) are engaged in the grooves and the housing and the end caps are firmly held together, said housing (1) comprising an inner cavity in form of an at least semi-cylindrical hole, which is not filled with a particulate arc-suppressing filling said housing (1) consisting at least in part of ablative material, which material dissociates at high temperature at least at its surface to release gases which suppress arcing when said fuse element blows.

2. A fuse according to claim 1, characterized in that at least the portion bounding the inner surface of the housing (1) is made of ablative material.

3. A fuse according to claims 1-2, characterized in that the fuse element consists of a carrier of ablative material with a thin coat of metal thereon.

4. A fuse according to claim 3, characterized in that the housing (1) comprises a solid portion in the form of a solid semi-cylinder (21), on which solid portion the thin metal coat (34) of the fuse element is arranged, and of a portion (22) hooding said solid portion which hood portion (22) substantially has the shape of a half, hollow tube.

5. A fuse according to claim 4, characterized in that the end caps (24, 25) are each provided with a central, inwardly directed, frusto-conical portion (35, 36) depressed from the end surface, and the solid portion (21) of the housing (1) is provided adjacent each of its ends with a semi-conical depression (32, 33) in its surface, on which the thin metal coat (34) is provided, the arrangement being such that the inwardly directed, frusto-conical portion (35, 36) of each end cap (24, 25) is in contact with the thin metal coat (34) provided in the adjacent conical cavity (32, 33) in the surface of the solid portion (21) of the housing.

6. A fuse according to claims 1-2, characterized in that bored plugs are provided within the housing adjacent each of the end caps, with the fuse element being passed through each of the bores to contact the end caps.

7. A fuse according to claim 6, characterized in that the bore through each plug makes an angle with the axis of the housing (1).

8. A fuse according to claims 6-7, characterized in that the housing (1) consists of a plastic material, and that the plugs are formed by an inwardly directed, thickened portion (18, 19) of the housing (1).

9. A fuse according to claims 1-2 and 6-8, characterized by the provisions of a pierced metal plate (20) within the housing adjacent each of the end caps.

Patentansprüche

1. Miniatur- und Subminiatursicherung, mit einer maximalen Abmessung von 6,3 x 32 mm und einer Ansprechstromstärke in der Größenordnung von 1500 A, mit einem zwischen zwei Abschlußkappen (3, 4) in einem Gehäuse (1) angeordneten Sicherungselement (2), welches an den gegenüberliegenden Enden mit den Abschlußkappen (3, 4) in Kontakt steht, dadurch gekennzeichnet, daß das zylindrische Gehäuse (1) zwei quer zur Achse des Gehäuses angeordnete Nuten (5, 6) aufweist, wobei die Abschlußkappen (3, 4) in die Nuten eingreifen und das Gehäuse und die Abschlußkappen fest verbunden sind, daß das Gehäuse (1) einen zumindest halbzylindrischen Innenhohlraum aufweist, welcher nicht mit einer aus einzelnen Partikeln bestehenden Lichtbogen unterdrükkenden Füllung gefüllt ist, und daß das Gehäuse (1) zumindest teilweise aus Ablationsmaterial besteht, das sich bei hohen Temperaturen zumindest an der Oberfläche zersetzt und Gase freisetzt, die bei Durchbrennen der Sicherung einen Lichtbogen unterdrücken.

2. Sicherung nach Anspruch 1, dadurch gekennzeichnet, daß mindestens der die Innenfläche des Gehäuses (1) bildende Teil aus Ablationsmaterial besteht.

3. Sicherung nach Anspruch 1 und 2, dadurch gekennzeichnet, daß das Sicherungselement aus einem mit einer dünnen Metallschicht überzogenen Träger aus Ablationsmaterial besteht.

4. Sicherung nach Anspruch 3, dadurch gekennzeichnet, daß das Gehäuse (1) aus einem massiven halbzylinderförmigen Teil (21), auf welchem die dünne Metallschicht (34) des Sicherungselementes angeordnet ist, und aus einem das massive Teil abdeckenden Teil (22), welches im wesentlichen die Form eines halben Hohlzylinders aufweist, besteht.

5. Sicherung nach Anspruch 4, dadurch gekennzeichnet, daß die Abschlußkappen (24, 25) jeweils einen mittig angeordneten, nach innen gerichteten, an den Abschlußflächen vertieften kegelförmigen Abschnitt (35, 36) aufweisen und daß das massive Teil (21) des Gehäuses (1) an den Enden in seiner Oberfläche eine mit der dünnen Metallschicht (34) überzogene halbkegelförmige Vertiefung (32, 33) aufweist, wobei die Anordnung so konstruiert ist, daß der nach innen gerichtete kegelförmige Abschnitt (35, 36) jeder Abschlußkappe (24, 25) mit der in der angrenzenden kegelförmigen Vertiefung (32, 33) in der Oberfläche des

festen Teils (21) des Gehäuses vorgesehenen dünnen Metallschicht (34) in Kontakt steht.

6. Sicherung nach Ansprüchen 1 und 2, dadurch gekennzeichnet, daß in dem Gehäuse angrenzend an die Abschlußkappen mit einer Bohrung versehene Stopfen vorgesehen sind, wobei das Sicherungselement zur Herstellung eines Kontakts mit den Abschlußkappen durch jede der Bohrungen geführt wird.

7. Sicherung nach Anspruch 6, dadurch gekennzeichnet, daß die Durchgangsbohrung in jedem Stopfen einen Winkel mit der Achse des Gehäuses (1) bildet.

8. Sicherung nach Anspruch 6 und 7, dadurch gekennzeichnet, daß das Gehäuse (1) aus Kunststoffmaterial besteht und daß die Stopfen durch nach innen gerichtete Erhebungen (18, 19) des Gehäuses (1) ausgebildet sind.

9. Sicherung nach Ansprüchen 1, 2, 6 und 8, dadurch gekennzeichnet, daß eine mit einer Bohrung versehene Metallplatte (20) in dem Gehäuse angrenzend an die Abschlußkappen vorgesehen ist.

Revendications

1. Un fusible du type miniature et sous-miniature ayant des dimensions ne dépassant pas 6,3 x 32 mm et ayant une capacité d'interruption de l'ordre de 1500 A, comprenant un élément fusible (2) disposé entre deux capuchons d'extrémité (3, 4) dans un logement (1), ledit élément fusible (2) étant aux extrémités opposées en contact avec lesdits capuchons d'extrémité (3, 4) caractérisé en ce que le logement cylindrique (1) comprend transversalement à l'axe du logement une paire de rainures (56) par lesquelles les capuchons d'extrémités (3, 4) sont engagés dans les rainures et le logement et les capuchons d'extrémité sont fermement maintenus ensemble, ledit logement (1) comprenant une cavité intérieure sous la forme d'au moins un trou semi-circulaire, qui n'est pas rempli avec un remplissage particulaire de suppression de l'arc, ledit logement (1) étant fait au moins en partie d'un matériau ablatif, lequel matériau se dissocie à une température élevée du moins à sa surface pour libérer des gaz qui suppriment le phénomène d'arc quand ledit élément fusible fond.

2. Un fusible selon la revendication 1, caractérisé en ce que au moins la partie limitant la surface intérieure du logement (1) est faite d'un matériau ablatif.

3. Un fusible selon les revendications 1-2, caractérisé en ce que l'élément fusible consiste en un support de matériau ablatif avec une fine couche de métal sur celui-ci.

4. Un fusible selon la revendication 3, caractérisé en ce que le logement (1) comprend une partie solide sous la forme d'un demi-cylindre solide (21), sur laquelle partie solide la fine couche de métal (34) de l'élément fusible est disposée, et d'une partie (22) recouvrant ladite partie solide laquelle partie solide (22) a essentiellement la forme d'un demi-tube creux.

5. Un fusible selon la revendication 4, caractérisé en ce que les capuchons d'extrémité (24, 25) sont chacun fourni avec une partie tronconique centrale (35, 36) dirigée vers l'intéreiur, évidée à partir de la surface d'extrémité, et la partie solide (21) du logement (1) est prévue près de chacune de ses extrémités avec une dépression semi-conique (32, 33) dans sa surface, sur laquelle la fine couche de métal (34) est fournie, l'arrangement étant tel que la partie centrale tronconique (35, 36) dirigée vers l'intérieur, de chaque capuchon d'extrémité (24, 25) est en contact avec la fine couche de métal (34) fournie dans la cavité conique adjacente (32, 33) de la surface de la partie solide (21) du logement.

6. Un fusible selon les revendications 1-2, caractérisé en ce que des tampons à trous sont fournis à l'intérieur du logement près de chacun des capuchons d'extrémité, avec l'élément fusible passé à travers chacun des trous pour faire contact avec les capuchons d'extrémité.

7. Un fusible selon la revendication 6, caractérisé en ce que le trou à travers chaque tampon forme un angle avec l'axe du logement (1).

8. Un fusible selon les revendications 6-7, caractérisé en ce que le logement (1) consiste en un matériau plastique et que les tampons sont formés par une partie épaissie (18 19) du logement (1) dirigée vers l'intérieur.

9. Un fusible selon les revendications 1, 2 et 6-8, caractérisé par les fournitures d'une plaque de métal percée (20) à l'intérieur du logement contre chacun des capuchons d'extrémité.

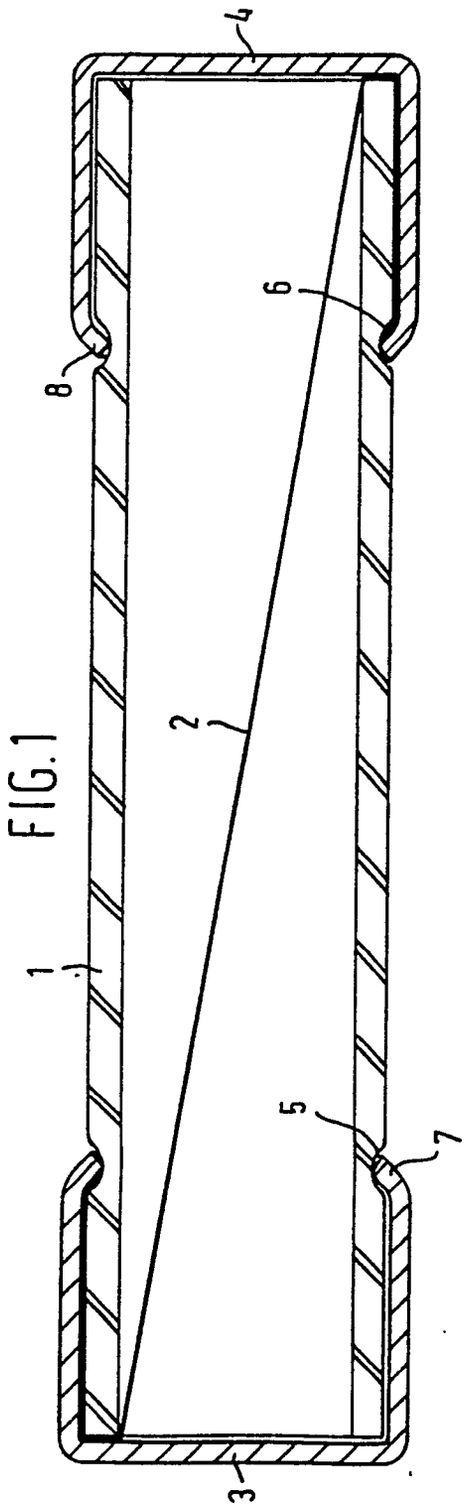


FIG.1

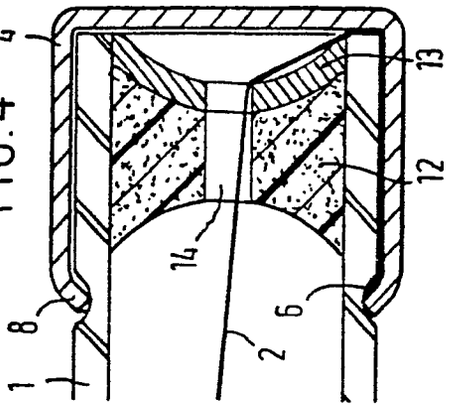


FIG.4

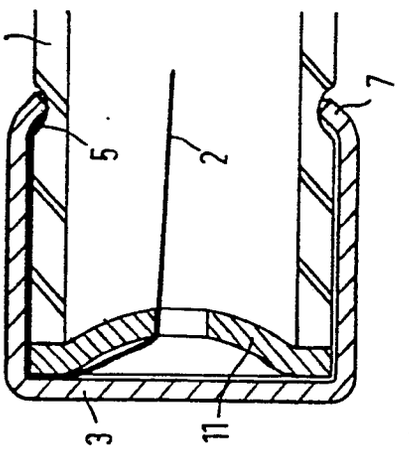


FIG.3

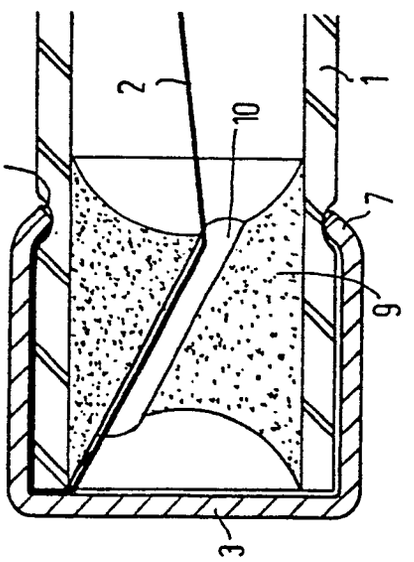


FIG.2

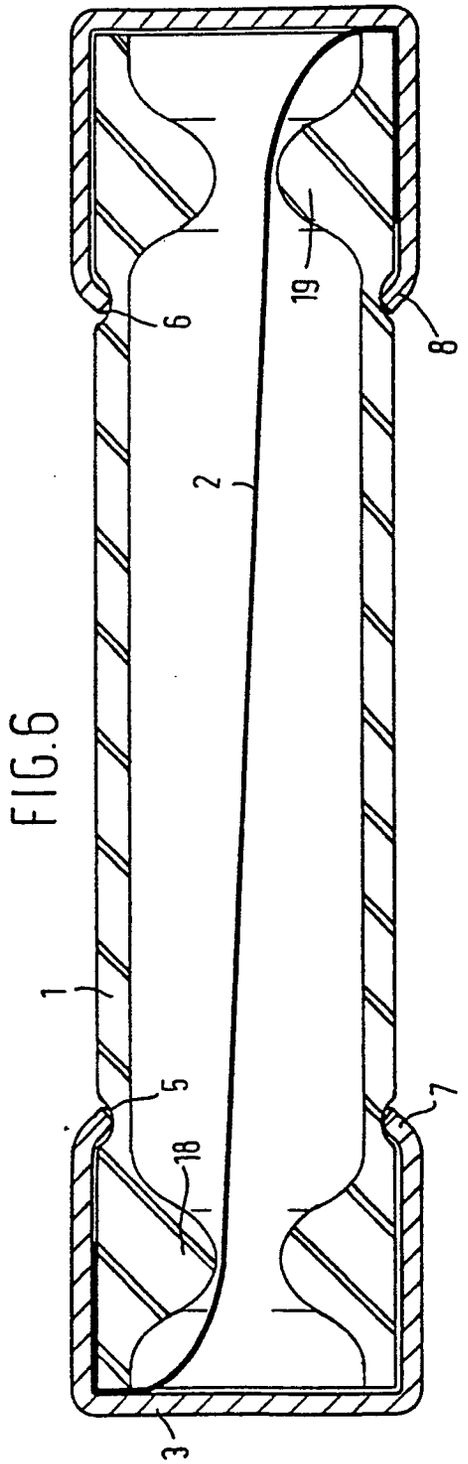


FIG.6

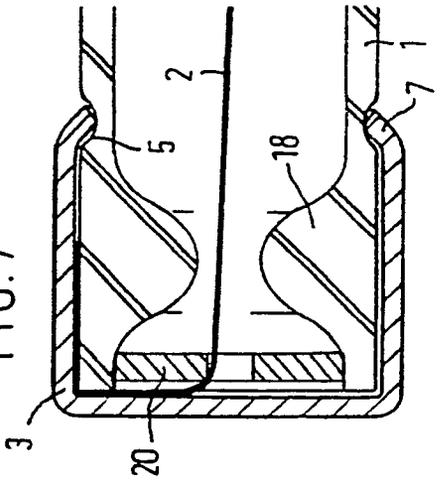


FIG.7

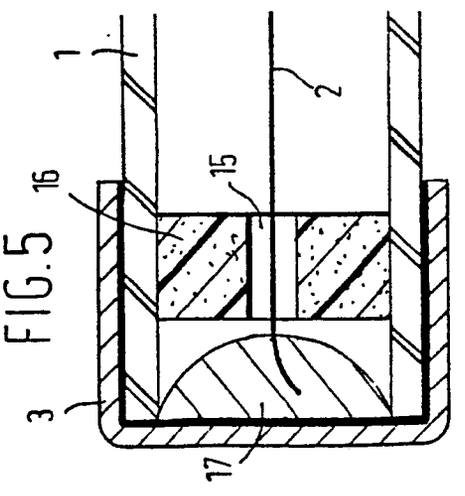


FIG.5

FIG.8

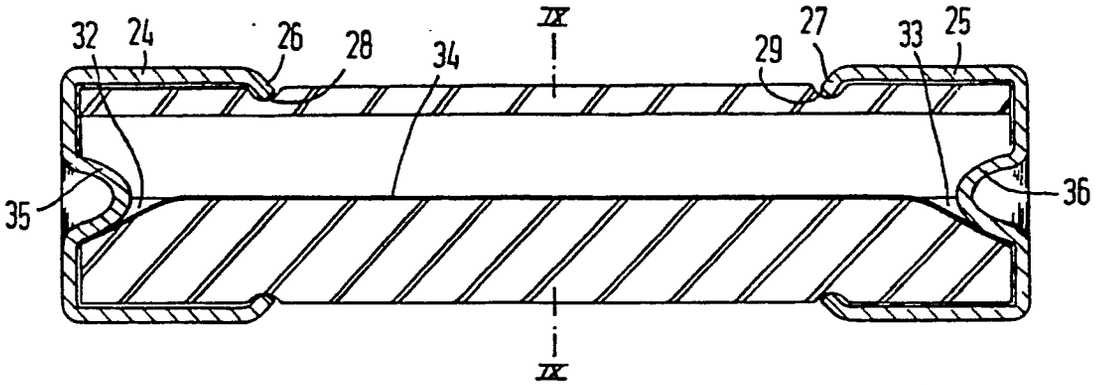
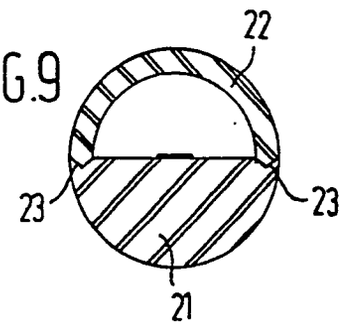


FIG.9



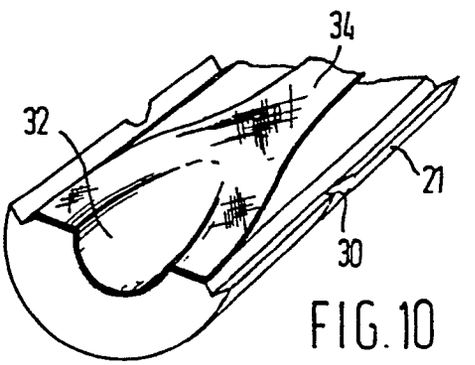


FIG.10